Space Weather Technical Forecast

Issued on Monday 31 March 2025 at 01:28 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Minor/Moderate (R1/R2) radio blackouts Expected. Active electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was High, with six M-class flares all most likely from AR4048 in the southeast. The peak flare was an M1.6 class flare at 30/1642 UTC. There are six sunspot regions on the Earth-facing disc. AR4048 is the largest and most complex, showing further growth in its intermediate spots in recent imagery. AR4043 spanning centre disk has shown a slight increase in it's intermediate portion. This was responsible for an M-class flare on 29 Mar and potential Earth-directed CME, though confidence is low. The rest of the spots show some moderate magnetic complexity but haven't been responsible for any significant flares.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as measured by ACE at L1, were indicative of gradual waning fast winds, emanating from CH25/+. The solar wind speed fell from Elevated back to slightly Elevated, 500 to 420 km/s. The solar wind density was below average throughout. The Interplanetary Magnetic Field, Bt, stayed steadily weak, around 5-6 nT throughout. The north-south component, Bz, varied between +/-5 nT. The phi angle was predominantly positive (away from the Sun) throughout. Geomagnetic activity was Quiet throughout (Kp1-2).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 was at background levels but with a rising trend. High energy electron flux (greater than 2 MeV) at GEO is High, peaking at 2770pfu at 30/1715UTC. The 24-hour integrated fluence exceeded Active at 29/1500 UTC, with the observed 24-hour integrated fluence 1.46e8pfu at 30/2359UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Further M-class activity is expected, with a slight chance of X-class activity.

Solar Wind / Geomagnetic Activity: Solar winds are expected to continue to wane on day 1 (31 Mar) as CH25/+ losses connection to Earth. Solar winds may then see an increase to elevated in the early hours of day 2 (01 Apr) due to a connection to a HSS from CH28/+, a much smaller feature than the last. Most CMEs in the last 24-48 hours are expected to miss Earth, however a weak CME from 29 Mar may be directed towards Earth, arriving on day 3 (02 Apr).

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Quiet to Unsettled geomagnetic activity is most likely. A chance of Active intervals and a slight chance of G1/Minor storm periods on days 2 and 3 (01/02 Apr) as Earth connects with CH28/+ and/or the CME from 29th.

Energetic Particles / Solar Radiation: High energy proton flux is above background levels on a rising trend and therefore there is a chance of rising above on day 1 (31 Mar), with a slight chance thereafter should any further notable flares occur.

High energy electron flux levels are above the High threshold and the electron fluence is above the Active threshold. These perhaps remaining above for the next two to four days, with slightly reduced confidence by 01 April with possible geomagnetic activity from either a CH HSS or an Earth-directed CME.

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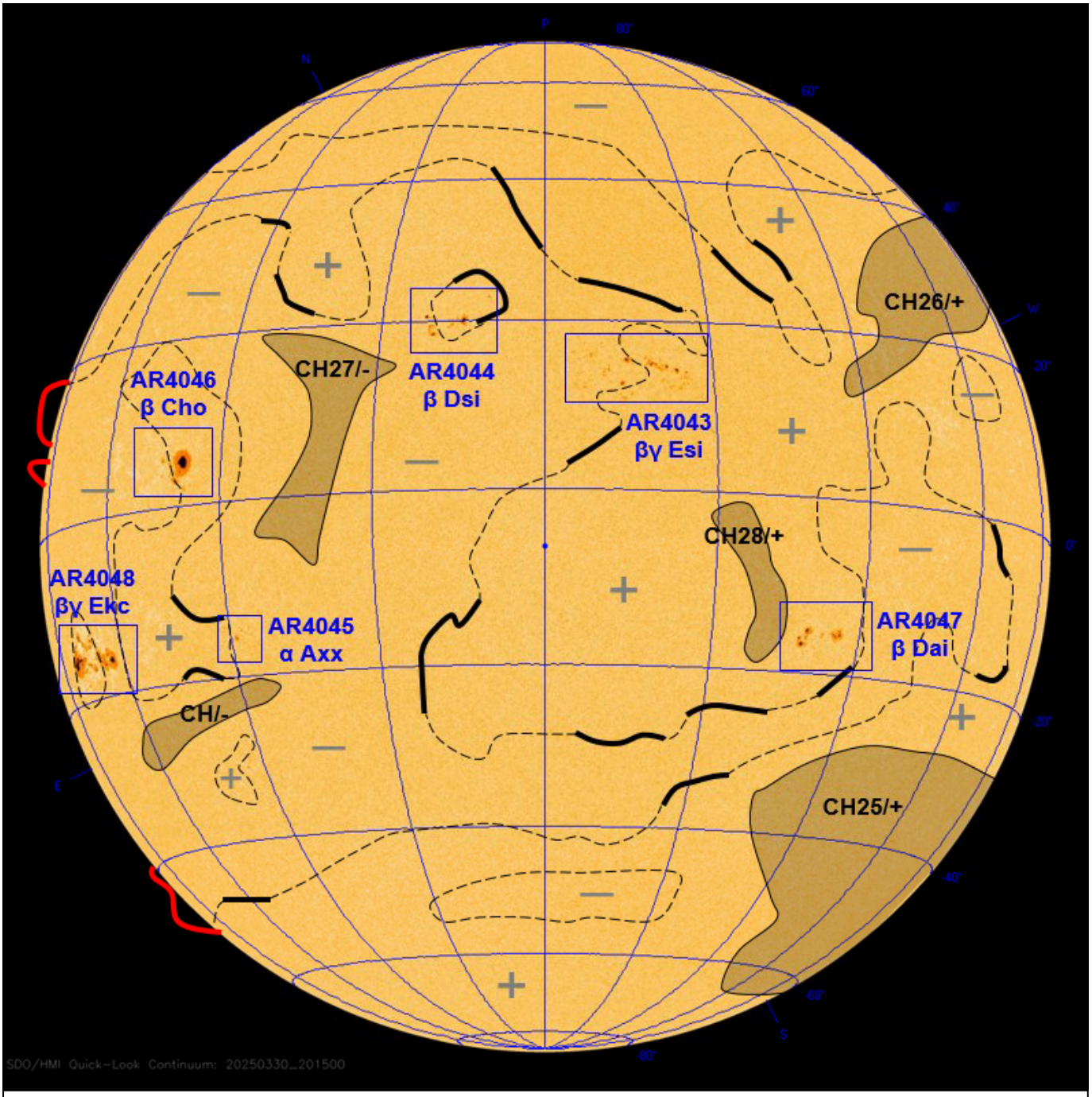
Figure 1: Solar Synoptic Map valid 30/2015 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Various weak CMEs appear to have left the Sun in the last 24-48hours, however, most look to be directed away from Earth with limited impact to the geomag. Imagery was limited for the CME related to the X1.1 flare on 28/1520 UTC, off the eastern limb in the vicinity of AR4046. However there is reasonable confidence that the bulk of the ejecta appears to head east behind the Earths orbit. There is a the potential for an Earth-directed CME, from the centre disc close to AR4043, on 29 Mar, though due to lack of triangulating imagery and a very faint signature this is very low confidence, but may bring a risk of enhanced geomagnetic activity on day 2 into day 3 (01-02 Apr). A CME also appears to have left the southeast limb on 29 Mar at around 2300 UTC (possibly in association with the M1.9 flare from AR4048), this is most like to pass behind Earths orbit. A rather fast CME then left the Sun later on 30 Mar from the northwest limb, there's good agreement that this will pass ahead of Earth.

Solar winds have been gradually easing as the connection to CH25/+ wanes and looses influence. There is a possible connection to CH28/+ signalled for late day 1 into day 2 (31 or 01 Apr) on Enlil, more probably the latter. MOSWOC Enlil output is considered to be providing a reasonably good steer on the solar wind forecast, if not perhaps overestimating the expected wind speeds from CH28/+ and too soon with its increase. Solar winds are therefore expected to fall back to slow-ambient speeds before rising to Elevated sometime between late day 1 into day 3 due to a combination of CH HSS and possible CME effects.

Quiet to Unsettled geomagnetic activity is most likely. A chance of Active intervals and a slight chance of G1/Minor storm periods on days 2 and 3 (01/02 Apr) as Earth connects with CH28/+ and/or the CME from 29th.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	20	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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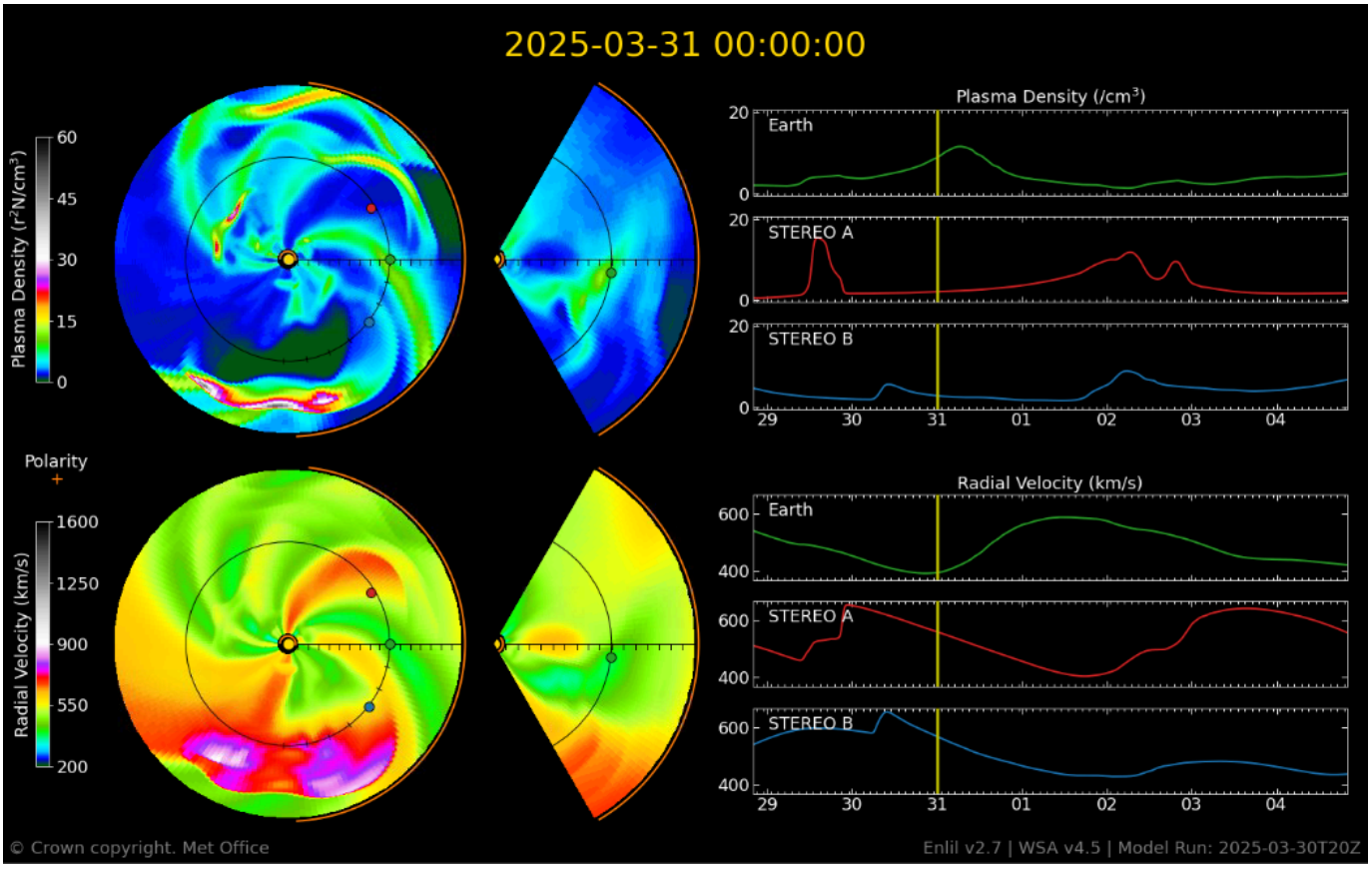
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
30/0800 UTC	Partial	Flare	North Centre	425	02/0000UTC	Very low confidence. Lack of triangulating imagery.

Figure 2: MOSWOC Enlil showing the fast CME from the X1.1 flare heading behind earths orbit. Meanwhile a steady increase in solar winds due to the HSS from CH28/+, the onset of which may be a touch too early and a touch too fast on expected wind speeds. Otherwise reasonable guidance.



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Radio Blackouts - X-Ray Flares

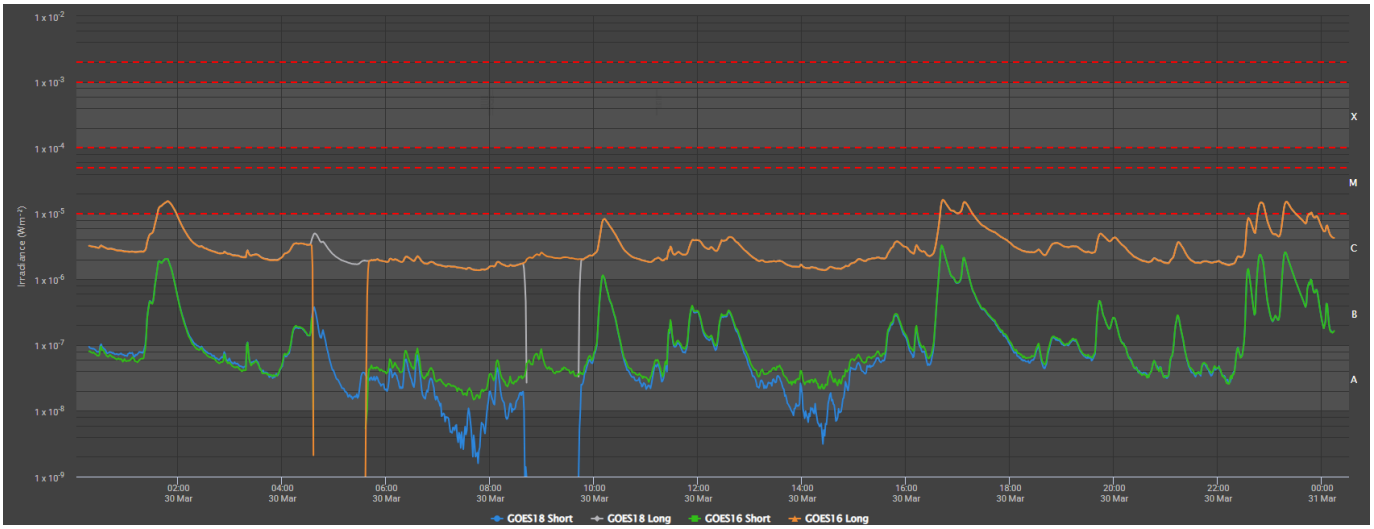
Solar activity was High, with six M-class flares all most likely from AR4048 in the southeast. The peak flare was an M1.6 class flare at 30/1642 UTC.

There are six regions on the current disc. AR4048 in the southeast, is a long, large and complex spot region, exhibiting continued growth in its intermediate spots. A large amount of magnetic looping continues to be observed and the region has been associated with several M-class flares, two of which may be in association with faint CMEs. AR4043 spanning centre disk has shown a slight increase in it's intermediate portion. This was responsible for an M-class flare on 29 Mar and potential Earth-directed CME, though confidence is low. AR4046 remains large and in recent imagery a trailing spot appears to be of opposite polarity becoming a beta spot. AR4047 in the southwest and AR4044 in the northeast both follow a similar developing trend, with both leading and trailing portions developing mature penumbra and spreading. The final active region is small and magnetically simple.

All considered, no significant regions depart in the four days, and the oncoming regions are perhaps already present, leading to a level trend. Due to some increase in complexity of active regions on the current disc, further M-class flares are expected with a slight chance of reaching X-class.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	80	80
Very Active	R3-R5 (X Class)	No	15	15	15	15

Figure 3: GOES16&18 X-ray flare trace.



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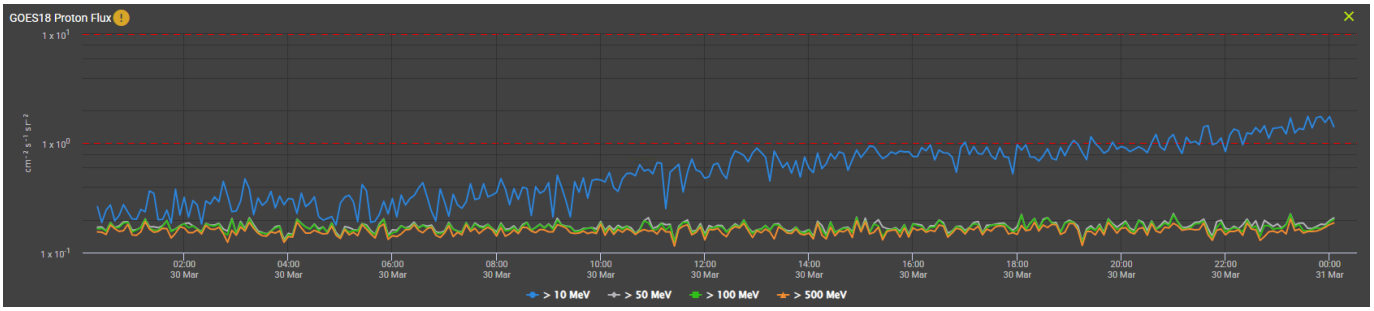
Solar Radiation Storms (High Energy Protons)

GOES18 high energy (>10MeV) proton flux was at or near Background levels initially, with a slight increasing trend through the first part of 30 Mar, this likely as a result of one, or a combination of the Moderate-class flares and associated CMEs leaving the Sun in the past 24 hours. The daily risk of S1 or greater starts as a chance today due to the recent enhancement, then falls to a slight chance for the remainder of the period, due to the westward advance of the far eastern active regions.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	30	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES18 Proton flux showing a rising trend.



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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2 MeV) has been above the High threshold for the past 24 hours and is likely to continue above the threshold initially, with a reducing trend. This, in part, due to the reduction in the HSS from CH25/+, any enhanced geomagnetic activity from a connection to the next CH28/+ on Day 1/2 (31Mar /01 Apr) and the possibility of a CME arrival on day 3 (02 Apr), which may serve to knock-out electron counts at GEO late in the period. Active levels of the 24-hour integrated fluence has been observed since 29/1500 UTC and are expected to remain Active through days 1 and potentially day 2 (31 Mar/01 Apr), before reducing confidence from day 3 onward.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	Yes	95	80	40	30
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: GOES16 Electron flux trace.

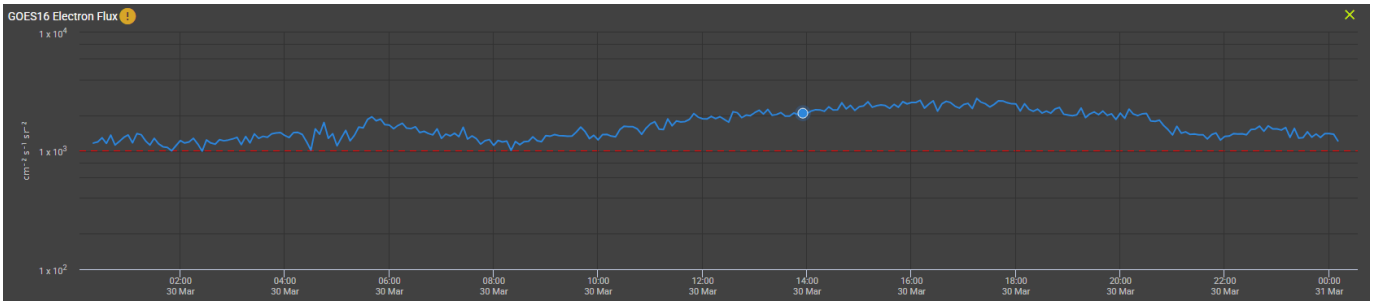

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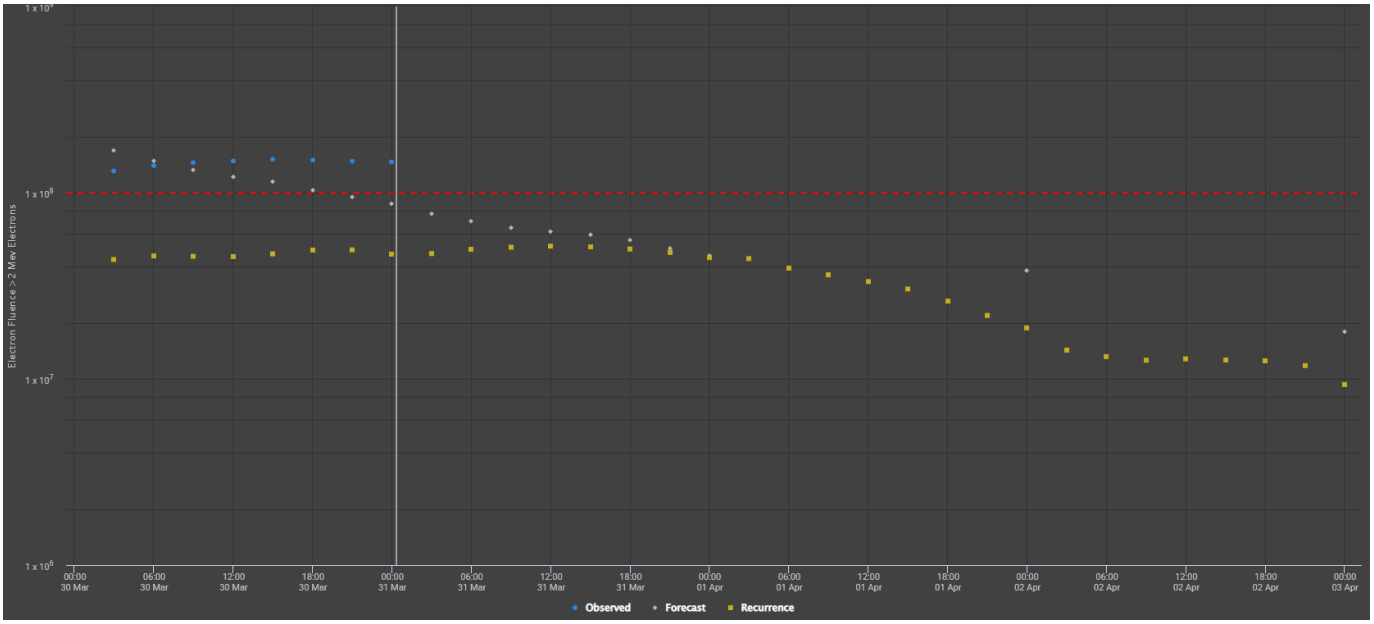
Figure 6: MOSWOC REFM output showing initially electron fluence is above the Active threshold but a declining trend.



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